Radiation Effects in Superconducting Magnets and Materials
Wroclaw University of Technology, Poland
12th – 14th May 2014

REPORT ON RESMM’14 WORKSHOP

Elena Quaranta

Collimation Upgrade Specification meeting
June 6th 2014
Workshop’s webpage - INDICO

https://indico.fnal.gov/conferenceOtherViews.py?fr=no&showSession=all&detailLevel=all&confId=7702&view=standard&showDate(all)

Workshop on Radiation Effects in Superconducting Magnets and Materials 2014 (RESMM'14)

from Monday, May 12, 2014 at 08:00 to Thursday, May 15, 2014 at 11:00 (Europe/Warsaw)
at Wroclaw University of Technology
Wybrzeze Wyspianskiego 27, 50-370 Wroclaw POLAND

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<th>International Organizing Committee:</th>
<th>Local Organizing Committee:</th>
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<tr>
<td>Maciej Chorowski (WrUT)</td>
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<td>Michael Eisterer (ATI)</td>
<td>Jarosław Poliński (WrUT)</td>
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<td>Rene Flukiger (CERN)</td>
<td>Błażej Skoczeń (CUT)</td>
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<td>Mike Lamm (FNAL)</td>
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<td>Nikolai Mokhov (co-chair, FNAL)</td>
<td>Piotr Wilk (WTP)</td>
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<td>Tatsushi Nakamoto (KEK)</td>
<td>Agnieszka Pelc (Coordinator, WrUT)</td>
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<td>Hiroshi Nakashima (JAEA)</td>
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<td>Koji Niita (RIST)</td>
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<td>Toru Ogitsu (co-chair, KEK)</td>
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<td>Al Zeller (FRIB)</td>
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RESMM’14: Objectives

Focus on establishing radiation damage limits and design of large superconducting systems, primarily for the Mu2e and Comet experiments, but also for ITER, LHC, FRIB and muon collider magnets.

- Design of superconducting magnets for high radiation environment
- Modeling of radiation effects in magnets and material response
- Benchmarking experiments
What I presented...

Comment by B. Skoczen: ACOUSTIC DEVICES for long-distance and on-line monitoring during destructive tests in HiRadMat facility?
What I found interesting for us...

Evolution of radiation induced micro-damage in the materials used in particle accelerators design

Błażej Skoczeń, Aneta Ustrzycka
Centre for Particle Accelerators Design, Cracow University of Technology

Collimator lifetime?!

The main task of the research

Task
We need to determine the lifetime of irradiated components, subjected to periodic thermo-mechanical loads in the course of their service

Method
Well calibrated constitutive model of micro-damage evolution in the irradiated components
State of the art in radiation induced damage

Irradiation induced defects in the lattice

Number of Frenkel defects created by a cascade as a function of kinetic energy of primary knock-on atoms

Source: D.J. Bacon, F. Gao, Yu.N. Gotskly, JNM 278, 2000

Irradiated metals and alloys: Copper

Defect concentration during irradiation - Aluminium

(for Al, after Verbiest and Pattyn, 1982)

Source: S.J. Zinkle „Microstructure evolution in irradiated metals and alloys: fundamental aspects”, Italy, 2004
Research programme

Experiments including neutron irradiated samples subjected to multiple loading/unloading technique

Building well calibrated multi-scale 3D constitutive models of damage evolution in the irradiated components in the framework of CDM

Combining CDM with fracture mechanics in order to predict transition from critical damage to fracture

Computing evolution of nano/micro damage fields and macro-crack propagation in the irradiated components

Lifetime prediction

Conclusion

The constitutive model has to be calibrated in order to achieve correct performance and obtain reliable results in terms of number of cycles to failure as a function of dpa
What I found interesting for us...

In-situ monitoring of high doses of radiation

Paweł Knapkiewicz
Faculty of Microsystem Electronics and Photonics
Division of Microengineering and Photovoltaics

RESMM 2014
Wrocław, Poland, 13 May 2014

Wanted: new method of measurements of high-doses of radiation above 20 kGy

Problem: no sensors
Our new MEMS sensor - principle

prior to irradiation
thin membrane

Si $P_0$

glass
HDPE

deflection of membrane
below maximal pressure/dose

Si $H_2 P_1$

glass
HDPE

Single membrane sensor
$P_1 < P_{\text{max}}$
proportional mode of detection possible

destruction of membrane
over maximal pressure/dose

Si $H_2 P_2$

glass
HDPE

"Cascade" membranes sensor
$P_2 > P_{\text{max}}$
membrane of known mechanical properties discriminates doses
**Possible applications:**

- an innovative, **maintenance free surveillance system** for the new generation nuclear power plant monitoring and nuclear reactor
- **dosimeter system** in high-level-waste storage places where the high dose monitoring is needed and in all facilities where the high energy particle accelerators exist (CERN, DESY, etc.).
Other ideas for the future...

e⁻ irradiation (A. Ryazanov):

👍 no radioactive sample after irradiation

🤔 correlation projectiles (type/energy) and damage in material needed

High doses radiation facility at NCBJ (Świerk-Poland): multipurpose LINAC up to 22MeV (6 MeV e⁻, dose rate >10 kGy/min)
Summary

- Acoustic devices for long-distance and on-line monitoring in HiRadMat tests
- Combining efforts with B. Skoczen in radiation-induced damage model studies
- Passive wireless MEMS dosimeters
- $\text{e}^-$ irradiation of collimator materials.
Wroclaw – Market Square

Thanks for your attention!